ASIAEX Horizontal Internal Wave Array

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LONG TERM GOALS

Our goals are to understand the physics of acoustic/internal wave interaction on the world's continental shelves, the acoustic signal variability resulting from such interaction, and the dynamics of shelf internal waves.

OBJECTIVES

We wish to quantify internal waves and acoustic/internal wave interactions in the spring 2001 ONR Asian Seas International Acoustics Experiment (ASIAEX). We also wish to determine the primary features and the dominant dynamical effects displayed by internal waves propagating past the acoustic equipment using many inexpensive moorings. An higher quantity of moorings than previous experiments provides broad and detailed horizontal sampling.

APPROACH

Our research uses temperature time-series data from many moorings in an area showing rich nonlinear wave activity, the ASIAEX 2001 area of the South China Sea between Taiwan and Hong Kong. This differs from other recent experiments simply by having more moorings. Those studies have also used moorings to measure the evolution of nonlinear, high-amplitude internal waves or wave groups in coastal waters. Unfortunately, the spacing between the moorings has typically been either too broad to fully resolve the development of the waves, or the moorings were sufficiently close together but not always in the most interesting place from a dynamical standpoint. Our approach should improve measurement and quantification of wave behavior. It must be emphasized that these temperature measurements do not stand alone. Twelve other moorings with physical oceanographic sensors were placed in the area, with eleven recovered, and daily seasoar surveys were made in the area.

Two technical approaches have been emphasized. The first is the use of less-durable, cheaper mooring technology than is typically employed, resulting in the Locomoor design (Low-cost). The second is the trading away of dense vertical sampling density in order to gain horizontal coverage without increasing cost. The small characteristic length scales of processes near the continental shelf edge

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14. ABSTRACT
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15. SUBJECT TERMS

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demand are very demanding to adequately sample without extraordinary numbers of instruments, creating these trade-offs.

WORK COMPLETED

We deployed eighteen Locomoors in the vicinity of the WHOI/NPS Horizontal/Vertical Line Array acoustic receiver, forming the Horizontal Internal Wave Array (HIWAY), Figure 1. Eleven were successfully recovered. Three of these were damaged by towed fishing gear but survived and continued to record data. The figure shows the other ASIAEX moorings, many of which had ADCP's, including the four nearest HIWAY. The ADCP velocity data are highly complementary to the HIWAY/Locomoor temperature data. The instrumentation was in the water from 22 April until 18 May 2001.

The Locomoors had no surface expression in order to safeguard them from human interference. The design was inexpensive and lightweight in comparison with the other ASIAEX moorings, Figure 2. At the upper end were ten plastic floats and an acoustically controlled recovery float and line pack held together with an aluminum frame. Beneath was a synthetic rope attached to a 933 lb anchor, with three thermometers taped and tie-wrapped to the rope. The thermometers were placed in the main thermocline so that high-frequency deviations could be converted to isotherm displacement. Spacing equal to ten meters between at least two if the sensors insured easy detection of ten-meter internal waves by high-frequency overlapping of temperatures.

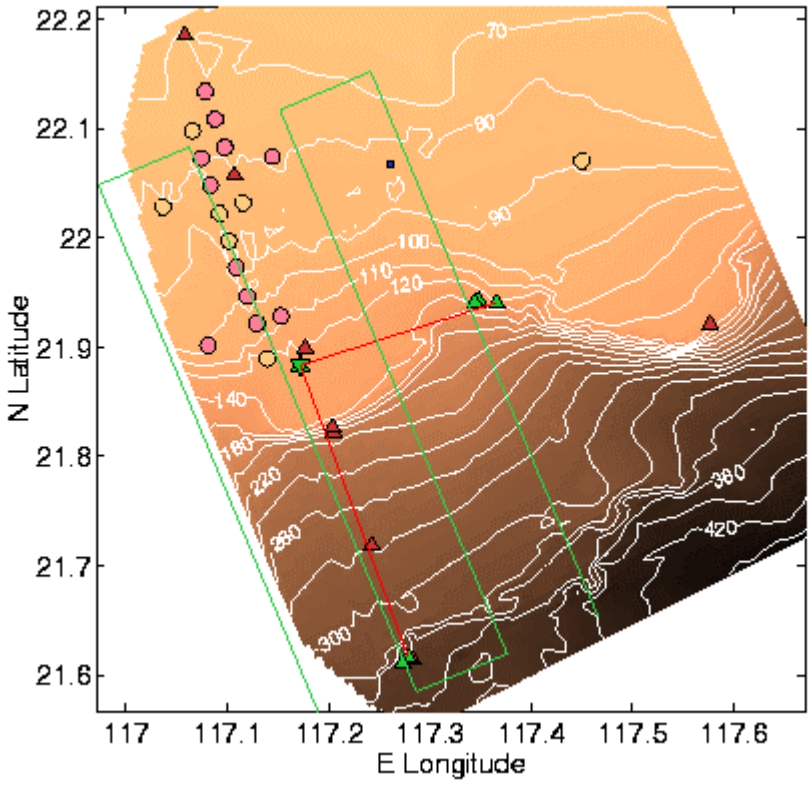

Figure 1. ASIAEX South China Sea site. The Locomoor/HIWAY is shown with circles. Eleven Loco's were recovered (pink) and seven were lost. The Seasoar track is shown in green. The red lines show acoustic transmission paths for moored components, with the HLA/VLA receiver at the vertex, and five sources at the other sites. The red triangles show physical oceanographic moorings additional to the Locomoor array which carried six ADCP's for measurement of internal wave velocities, including the four sites nearest HIWAY. Depths are in meters.

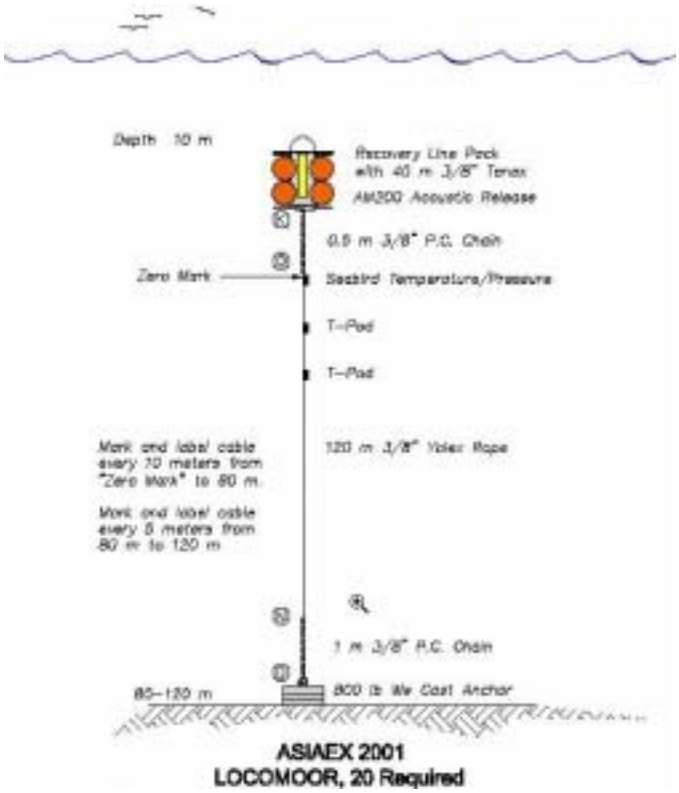

Figure 2. Components of the Low-Cost Mooring, Locomoor, are shown.

The many moorings will enable continuous two-dimensional horizontal wave mapping, allowing study of wave formation, wavefront interaction, refraction, and energy flux. Towed hydrographic data were collected daily for eight days along the track shown in Figure 1 by Glen Gawarkiewicz and colleagues, which may allow accurate calculation of internal-wave displacements. This can be tested at the other moorings with vertically dense thermometers. The HIWAY data will be combined with other moored sensors in the area and with synthetic aperture radar images to give the best possible temporally continuous picture of the wavefield. Detrimentally, only four commercial acoustic releases functioned, despite prior testing. One Locomoor was at the surface because the rope was too long. Six were located visually beneath the surface and were recovered with a small boat operation by John Potter and Koay Teong Beng of National University of Singapore and Will Ostrom of WHOI, with the able assistance of the crew of the vessel *Ocean Researcher 1 of* National Taiwan University. Lost moorings may simply not have been seen.

RESULTS

At this time we are both working to organize the HIWAY and the other ASIAEX data for distribution to all project PI's, so we have not obtained any meaningful results. We are still in the process of post-cruise calibration of the inexpensive Locomoor thermometers. These appear to have worked well. Our major result for this year is thus the successful collection of internal wave data in this interesting marginal Asian Sea. Figure 3 shows data from the eastern Locomoor in the northern recovered group (see Figure 1). Figure 4 shows the marginal coherence between stations spaced at roughly 10 km.

Fortunately we have closer station spacings\, so rapid evolution of the highly nonlinear waves may be well-enough sampled to allow meaningful comparison with theory.

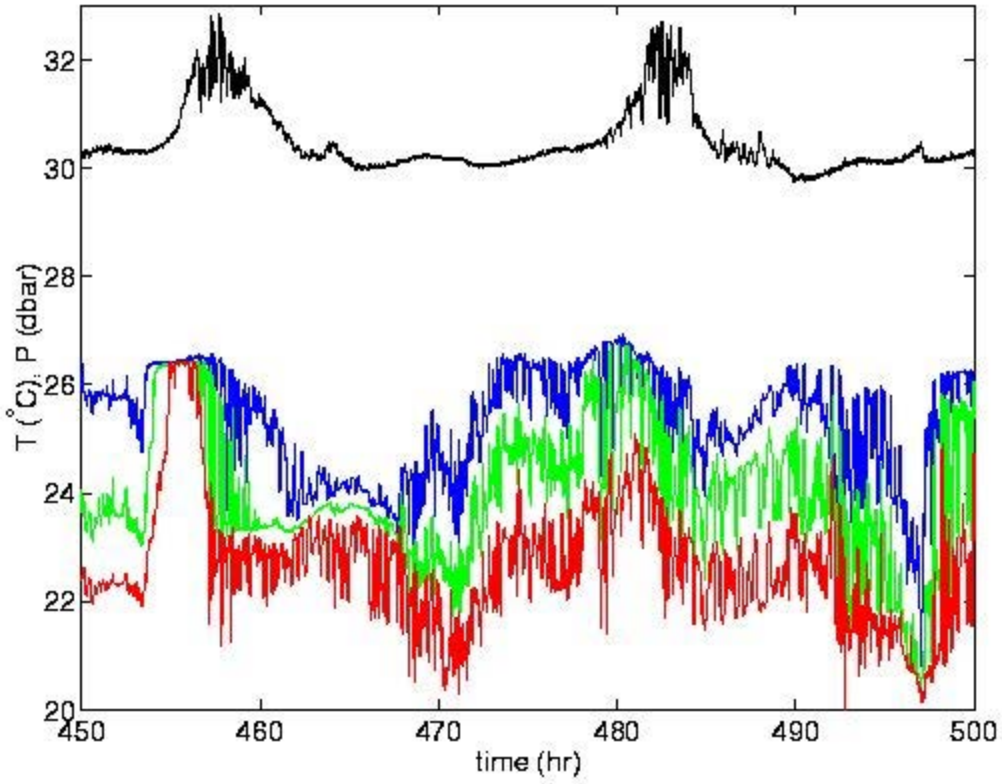

Figure 3. Loco16 data are shown. This is the mooring to the east in the northward recovered group. Depth was 80, sensors at 30, 40 and 50 m depth. The pressure signal (black) shows a typical small mooring pulldown which can be dealt with. The temperature records in the short segment of 675 hours of data show many waves exceeding 10-m amplitude (the sensor spacing) and some of 20 m.

IMPACT/APPLICATIONS

The strongest immediate impact of these data will come from comparison with Mid-Atlantic Byte data showing somewhat different wave behavior, and from quantitative comparison of wave passage with ASIAEX acoustic fluctuations The acoustics were moved away from the environmental moorings at the last minute, however, so comparison may require wave backpropagation from the array.

TRANSITIONS

Our first transitions will be to ONR Capturing Uncertainty DRI projects, and to other investigators interested in acoustic fluctuations generated by high-amplitude internal waves. The wave data will undoubtedly be of interest to nonlinear internal wave theoreticians and modelers.

RELATED PROJECTS

This project was undertaken under close collaboration with the ONR ASIAEX Volume Interaction Experiment (acoustics) under the direction of Dr. James Lynch, and the Frontal Studies in the South China Sea project of Drs. Gawarkiewicz, Beardsley and Brink, all of WHOI. There are many other related projects under the ASIAEX umbrella. Many of the projects of the Capturing Uncertainty DRI are also related. Related past projects are the SWARM and PRIMER acoustics/shelfbreak front internal wave/acoustic experiments and an acoustic/internal wave interaction modeling study of Duda and Preisig.

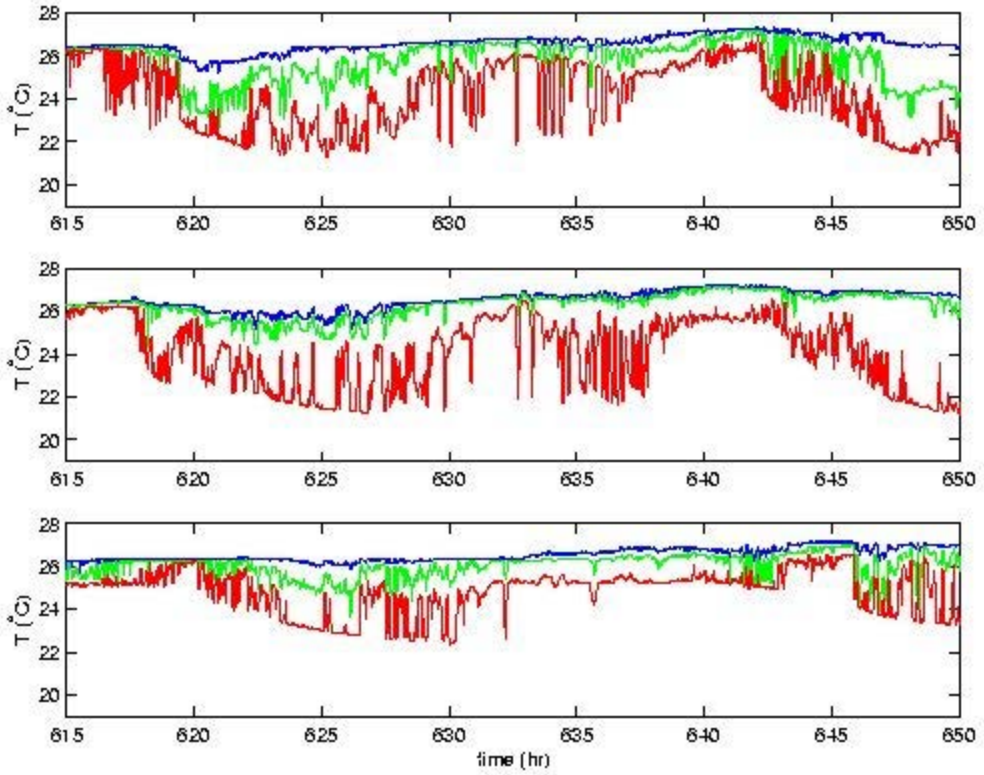

Figure 4. From the top are shown data from Loco16, Loco9 and Loco13. These form the largest triangle in the northern group (Figure 1), with 16 to the east, 13 to the north, and 9 to the southwest. Water depths were 80, 85, and 75 m. . There are three additional Locomoors within the triangle with comparable data. Many of the waves or wave packets can be seen at all three moorings, although packet details often differ. The signals at 635 hours in Loco16, which exceed 10 m amplitude, are conspicuously absent from Loco13.

PUBLICATIONS

A. Newhall, L. Costello, T. Duda, J. Dunn, G. Gawarkiewicz, J. Irish, J. Kemp, N. McPhee, S. Liberatore, J. Lynch,, W. Ostrom, T. Schroeder, R. Trask, K. Von der Heydt, "Preliminary acoustic and oceanographic observations from the ASIAEX 2001 South China Sea Experiment", WHOI Technical Report, Sept. 2001.